

Ammonia based membrane
reactor for green Hydrogen

Welcome to this second ANDREAH newsletter!

ANDREAH is a four-year European project, whose main objective is to provide a quantum leap in the development of advanced ammonia decomposition technologies to produce ultra-pure hydrogen (>99.998%) by developing an innovative system based on a Catalytic Membrane Reactor (CMR) for the cracking of Ammonia. In this way, optimised heat management, improved conversion per pass and purification/recycling for more cost-efficient and resource-effective ammonia decomposition at lower temperatures compared to conventional systems will be achieved.



The present newsletter is the second release of the biannual letter that will be published by AndreaH presenting the progress on the project and highlighting information related to the R&D fields addressed. Hope you will find the info in this newsletter interesting.

On our website <http://www.andreahproject.eu> you will find public presentations, all the public deliverables of the project and many other interesting news. Stay tuned!



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Newsletter Issue 2, in this number:

About the project p. 3
ReCup from last months p. 4
News from TU/e p. 7
Meet our Researcher: p. 8
Dissemination p. 9



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About the Project

ANDREAH is clustered around 3 phases, which will allow the smooth and sound transition from current development stage of the technologies to a validation at TRL 5.

As shown in the below picture, the ANDREAH methodology comprises upstream R&D activities of the proposed technologies, followed by selection and development of the final prototype.

Finally, the validation of the main selected technology will take place and the main KPIs for hydrogen production from NH_3 will be analysed.

Phase 1 – R&D (M1-M24): led by the universities, RTOs and industrial partners, this Phase is mainly focus on the optimization of key building blocks (Membranes, catalysts, sorbents and Reactors). Most of the experiments during this phase are performed at laboratory or small scale. The key components in this phase will be developed by TEC (membranes), CNR and UMI (Catalysts) and TUE (sorbents and reactors).

The main research areas that are explored within the R&D phase of ANDREAH as well as how we will go beyond the state of the art are explained in detail below, following the key components of the concept.

Moreover, this R&D phase is organised into three different pillars:

- The first pillar includes modelling activities (by TUE) to guide R&D partners on the best combination of catalyst, sorbents, reactors and membranes to guide the experiments in an effective way.
- In the 2nd pillar, experiments with H_2 and NH_3 process that are well known for the R&D partners will be carried out first to validate the modelling.
- Gradually, R&D partners will move towards pillar 3 where they will perform experiments combining different components together as well as more complex streams based on the knowledge acquired in the first and second pillars.

A Design of Experiment approach will be used to find the best combination of parameters and processing routes for the different key components. This will reduce drastically the number of experiments needed in order to find the optimal combination of key building blocks.

The final outcome of Phase 1 will be the selection of the key components for their scale up in Phase 2. However, R&D on lower TRL components will also be made within the project to obtain direct indications on alternative solutions (up to TRL4).



Looking back to the last months, the partners of ANDREAH project were very busy on their work and activities.

Thanks to the collaboration of other projects, where both Tecniaia and 1Cube are partners, the project has been presented in 2 big Symposium:

- **9th Symposium on Hydrogen, Fuel Cells, and Advanced Batteries, (HYCELTEC)** in Milazzo (Sicily) from June 30th to July 3rd, 2024.



HYCELTEC was a great opportunity to discuss the latest advancements in fuel cells, hydrogen, and batteries. Researchers from academia, industry, and technological centers will be coming together to share their knowledge.

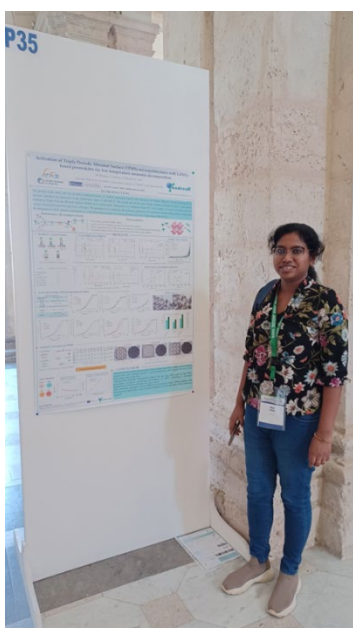


The 3rd and last day of Symposium, in the *Session of Hydrogen* there were three presentations by V. Cecchetto and F. Gallucci from TUE and A. Pacheco from Tecniaia.





Moreover M. Thomas from our partner CNR-ITAE made a poster about *“Activation of Triply Periodic Minimal Surface (TPMS) microarchitectures with LaNiO₃-based perovskites for low temperature ammonia decomposition.*



The present work deals with the synthesis, characterization, of LaNiO₃ based perovskites with varying A site dopant (Mg,Sr,Ce,Y) and investigation of catalytic ammonia decomposition in the temperature range of 300-600 °C.

The second part of the work include catalytic activation of (by a wash-coating method) of Triply Periodic Minimal Surface (TPMS) microarchitectures 3D-printed in a cylindrical shape (Ø = 1cm, Length = 1.5 cm), in Ni-alloy and with various structural parameters (porosity, cell type).

The general aim is to intensify the hydrogen generation with structured catalysts with geometries that allow the integration with H₂ selective membranes in a membrane-based reactor to increase productivity at low temperatures (300-450°C).



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Presentations and Poster are in [Dissemination page](#) of our website www.andreahproject.eu

- **6th ISPCEM 2024** (*International Symposium on plasmas for catalysis and energy materials* in Eindhoven (The Netherlands))



ISPCEM serves as a platform for experts in plasma technologies for energy, environmental catalysis, and energy materials to convene. It offers a valuable opportunity for researchers, industry professionals, and academics to exchange knowledge, discuss innovations, and explore the latest advancements in plasma applications.

It was a great opportunity to ANDREAH project to be present at this Symposium organized by 1 Cube in collaborations with TU/e and other two projects where Tecnia also in involved as Coordinator.

In 1Cube Youtube- channel there is also a video of those important days.

<https://www.youtube.com/@1CubeBV>



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Last paper at the **TU/e SUSTAINABLE ENERGY and PROCESS TECHNOLOGY** cluster in the framework of ANDREAH project has been just published.

The research group Sustainable Process Engineering is part of the Faculty of Chemical Engineering and Chemistry at the Eindhoven University of Technology. The main objective of the research group is the development of novel integrated reactor concepts (such as membrane reactors, micro reactors, structured catalysts and reactors) based on improved fundamental knowledge using validated advanced (multi-phase) reactor models.

This is achieved by employing a combination of state-of-the-art numerical models (at different levels of detail using the multi-level modelling approach), advanced (noninvasive) experimental techniques and experimental demonstration of novel reactor concepts (proof of concept).

The published paper about “Carbon Molecular Sieve Membrane Reactors for Ammonia Cracking” by V. Cechetto, G.o Anello, A. Rahimalimamaghani and Prof. Fausto Gallucci shows the use of carbon membrane-based ammonia decomposition and it is a first step for the scaling of this technology.

And it's open access at MPDI Processes:



Article

Carbon Molecular Sieve Membrane Reactors for Ammonia Cracking

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Abstract: The utilization of ammonia for hydrogen storage relies on the implementation of efficient decomposition techniques, and the membrane reactor, which allows simultaneous ammonia decomposition and hydrogen recovery, can be regarded as a promising technology. While Pd-based membranes show the highest performance for hydrogen separation, their applicability for NH₃-sensitive applications, such as proton exchange membrane (PEM) fuel cells, demands relatively thick, and therefore expensive, membranes to meet the purity targets for hydrogen. To address this challenge, this study proposes a solution involving the utilization of a downstream hydrogen purification unit to remove residual ammonia, thereby enabling the use of less selective, therefore more cost-effective,

From this paper, 1Cube made also a video that is available on YouTube channel [click here](#)



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Valentina Cechetto is a Postdoctoral Researcher at Eindhoven University of Technology, in the Sustainable Process Engineering group.

After completing her secondary education at Liceo Classico in Vigevano, Italy, her academic journey began at Politecnico di Milano, where she obtained a Bachelor's and Master's degree in Energy Engineering specializing in power production.

During her Master's, she carried out her thesis project in the Multiphase Reactors group at Eindhoven University of Technology under the supervision of Prof. Dr. Eng. F. Gallucci.

Her thesis, titled "Carbon Membranes for the Selective Separation of Industrial Gas Mixtures", sparked her deep interest in chemical processes and research. Inspired by this experience, Valentina pursued an Engineering Doctorate (EngD) in Process and Product Design at Eindhoven University of Technology. Under the guidance of Prof. Dr. Eng. M. van Sint Annaland, she focused on the "Process Design for Chemical Looping CO₂ Hydrogenation to Methanol", which earned her the EngD title.

Driven by her passion for research, Valentina continued her academic journey by enrolling in a PhD program in the Sustainable Process Engineering group at the same institution. Her research, supervised by Prof. Dr. Eng. F. Gallucci, focused on the development of membrane reactors for hydrogen production from ammonia. In May 2024, she successfully defended her PhD thesis titled "Ultra-pure Hydrogen Production via Ammonia Decomposition in Packed Bed Membrane Reactors".

Currently, as a Postdoctoral Researcher, Valentina's research focuses on bringing the knowledge and insight gained during her PhD into real application and in ANDREAH project her goal is to investigate materials and solutions which could help bridging the gap between research and application. Valentina's hope is to be able to drive real-world impact in the field of clean energy generation.





On 17th October 2024, 1 Cube organized a webinar about "Ammonia as Energy Carrier" with two projects: AMBHER project and ANDREAH project.

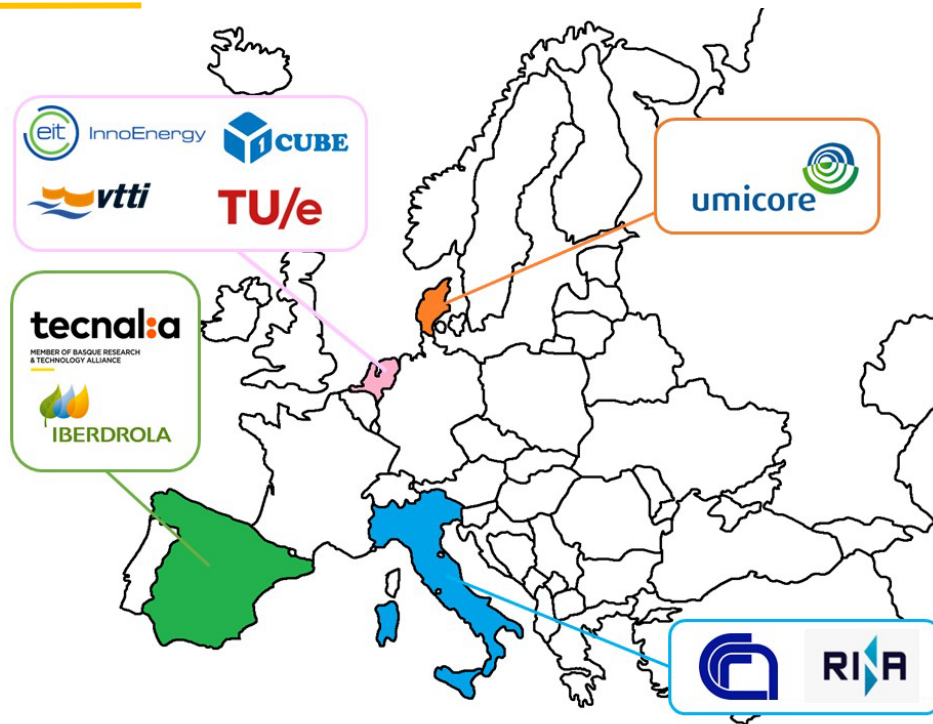
The webinar started with the introduction of the Coordinator of the two projects and continued with the presentation about "*Catalysts for ammonia synthesis and ammonia decomposition*", followed by a "*Scale Up of structured catalysts for ammonia synthesis*" and "*Membranes for ammonia separation*" and ended with a "*Membrane reactors for ammonia decomposition*"

The discussions were well-received, providing attendees with valuable insights into catalyst technology, membrane solutions, and reactor systems.

The webinar has been recorded and uploaded in ANDREAH website. Also, the presentation slides are available on our website: www.andreahproject.eu

Explore the content at your convenience and catch up on the latest developments in ammonia-based energy solutions.





Project details:

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Project Acronym: ANDREAH

Call: HORIZON-JTI-CLEANH2-2022-2

Starting date: July 1st 2023

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Coordinator: Fundaci3n Tecnal:a Research & Innovation

Project Coordinator: Jos3-Luis Viviente, Jaione Olo Loinaz



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